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quadric cone, consists only of the *right line* pt itself, and of the *osculating twisted cubic* to the proposed curve in space.

XII. These are only *specimens* of *one set* (as above hinted) of recent results obtained through quaternions; but at least they may serve to mark, in some small degree, the respect and affection, to the Academy, and to yourself, with which I remain,

My dear Mr. President,

Faithfully yours,

WILLIAM ROWAN HAMILTON.

*The Very Rev. Charles Graves, D. D., P. R. I. A.,
Dean of the Chapel Royal, &c.*

The following donations were presented to the Museum :—

1. A cinerary urn, of a peculiar form, ornamented with ribs and undulating lines, forming patterns, charged with sloping straight lines, made apparently with the teeth of a comb; height 4 inches, diameter $5\frac{1}{2}$ inches. Presented by R. H. Frith, Esq., C. E.

2. Three small cleft rings, from Thebes, in Egypt, composed of alabaster, cornelian, and bronze, or copper plated with gold, like certain cleft rings found in Ireland. Presented on the part of Arthur R. Nugent, Esq.

3. Four flint arrow-heads, said to be recently manufactured at Cambridge. Presented by F. J. Foot, Esq.

The thanks of the Academy were returned to the several donors.

MONDAY, MAY 11, 1863.

WILLIAM R. WILDE, Esq., Vice-President, in the Chair.

On the recommendation of the Council, it was—

RESOLVED,—That the sum of £50 be placed at the disposal of the Council for the purchase of antiquities, and for the arrangement of the Museum, for the year 1863–64.

The Rev. William Reeves, D. D., read a paper “On Irish Ecclesiastical Shrines.”

Mr. E. CLIBBORN, with the permission of the meeting, read the following paper :—

ON THE SPARKS PRODUCED BY THE IRON INDUCTION COIL USED BY THE
REV. DR. CALLAN, OF MAYNOOTH.

HAVING had an opportunity given me on Tuesday, the 21st ult., by the Rev. Dr. Callan, professor of natural philosophy in St. Patrick’s College, Maynooth, of seeing his gigantic induction electro-magnetic helix in full action at his lecture on that day, and having then noticed

certain phenomena which are not, I believe, generally known, I venture to call attention to them.

Those I propose to notice here relate altogether to the action of the secondary or induction helix, composed, as Dr. Callan explained to his class, of thirty miles of iron wire, of about the hundredth of an inch in thickness. The wire was wound up into three flat rolls or block wheels, which were placed at equal distances on the central facies of iron rods composing the core. These rods, about three feet long, were bound round by a helix of thick copper wire, laid on in three strata, extending from about three inches of their ends.

The secondary helix was in connexion with a multiplying apparatus, composed of several hundreds of sheets of a large quarto paper with tin foil between them, which was, like the coating on the iron wire, all insulated by means of varnish invented by the professor.

The primary or thick copper wire helix, at the time the experiments I here refer to were performed, was in connexion with from one to six four-inch plates of Dr. Callan's galvanic battery;* and the action, though extraordinary in producing sparks or miniature flashes of lightning, in some cases sixteen and a half inches long, between the ends of the secondary helix, on breaking the contact of the ends of the primary helix, was inferior, it was stated, to that of a larger apparatus, lately exhibited in London, the cost of which, compared with that constructed by Dr. Callan, was said to be exorbitant.

In Dr. Callan's apparatus, every care has been taken to produce the greatest philosophical results at a minimum cost. Wood, iron, zinc, tinfoil, and paper, are the chief materials. Brass is used only in the break of the primary helix, and the nice works connected with it, but otherwise everything indicated the greatest economy, combined with complete operativeness, equal to any elaborate instrument that could be produced in the workshop of the most fastidious electrician.

The sparks produced by the secondary helix passed, either between its two terminal points, or from one point to a large slightly concave circular disk, to which the other end of the helix was attached. Under certain circumstances, these sparks differed from each other, and also from any other electric sparks I had seen before; their apparent difference becoming less and less with the decrease of the distance of the point between which the sparks passed.

When the sparks were over six or seven inches in length, the shape of no two of them appeared to be the same. They were all contorted more or less; and when the distance was the greatest, and when the spark would hardly pass, its zigzag or broken character gave it the appearance of a miniature flash of lightning. In every case the spark

* Dr. Callan has communicated the following details:—One cell gave sparks $7\frac{1}{2}$ inches long; two cells gave sparks $12\frac{1}{2}$ inches long; and six cells gave sparks $16\frac{1}{2}$ inches long.

was accompanied with a peculiarly sharp disagreeable crack noise, as if two extremely hard things had been struck together; but no two of the reports, when the spark was very long, appeared to my ear to be exactly the same, some being a little louder or sharper than others. In ordinary electric machine sparks, taken from the prime conductor with a ball placed at a certain distance, the sounds are, I believe, uniformly the same, and to my ear more distinct; but such is not the case with the sparks produced by this great induction coil, when they are long. It appears as if they must be different also when they are short; but my ear failed to notice it, while the eyes of some other observers appeared not to notice a difference of another kind in the sparks.

This is the occasional difference of colour between the right and left halves of the sparks produced by the induction helix, when they are about from three to five inches in length. Supposing an observer to stand in front of the apparatus, the half of the spark to his left hand, coming from the inside terminal, always exhibited more or less a bluish-white light, similar to that of sparks produced by approaching some conducting substance towards the prime conductor of a common electric machine when in good working order; but the half of the spark towards his right hand, or outside terminal of the helix, had always a different colour. It was a sort of orange-red or salmon-colour, and fainter than the other, and less luminous,—suggesting to a believer in the doctrine of two electric fluids an essential difference in the colour of each, the bluish-white being the proper colour of one electricity, the orange-red or salmon-colour, the peculiar colour of the other electricity.

I here merely indicate the difference of colour observed between the different ends of the sparks produced by the secondary helix, without proposing any theory to account for it. I state the fact as one I observed, which indicated a characteristic difference between the electric sparks produced by this helix and electric sparks produced by another agency.

If one carefully watched the sparks composed of a left half of whitish-blue, and a right half of salmon-coloured light, they would see very often the salmon-coloured light form a fringe, or rather a case, to the other, extending itself towards the left, beyond the medial point, up to, if not to the starting-place of the white spark; which would in cases of this kind pass, as it were, through the centre of the salmon-coloured spark to the place it issued from: yet the eye could not detect a difference in the moments of departure of the sparks. The spark thus appeared to be one composed of two colours; and to me it appeared to always start from the right point. To other observers it appeared to pass from the left. Hence this apparent difference may be due to peculiarity of vision, peoples' eyes having different sensibilities, like their ears—a fact well known to astronomical observers. In every case the duration of the spark may have been so short that it was nearly instantaneous, though the impression of it on the eye might have endured as long as any other flash of light of the same intensity. Thus, no

doubt, it appeared to exist or give light much longer than it did, we judging by our sensations only.

The character of the short spark sometimes differed from that just noticed, the colours extending only half way; still the two colours continued the same, and each held its peculiar character, the blue-white light appearing to be compact and uniform, like the centre of a sheet of perfect flame, while the salmon-colour appeared like the edge of the flame of a lamp of impure hydrogen, having a character like hair or luminous filaments, striking away in all directions into space, but of its own peculiar colour.

In some cases where the difference of colour of the halves of the spark were most distinctly observable, as if they did not mix or overlap each other, a knob or ball excrescence appeared in the centre of the spark. Its core was always composed of the bluish and white light, surrounded with the salmon-coloured. Here in the centre of the space between the two points, the advocate of the doctrine of the two electric fluids might tell us, they met and fought; and that while the salmon-coloured fluid devoured the blue and whitish fluid, the latter exploded, totally destroying all appearance and trace of its enemy.

When the sparks were long, we could notice a difference in their colour, and in intensity or quantity, no two sparks appearing to be exactly alike, but I did not notice any knobs on those sparks; yet I suspect that there may have been such lumps at every joint, angle, or break, in the continuity of the line which these long sparks made in their passage through the air, though we did not notice them.

In machine electricity it is generally said that sparks pass between the nearest points, or shortest distances, but this statement is to be received under correction; for sparks taken from prime conductors of different shapes are themselves different to each other. And if a prime conductor of an electrifying machine be very long, the sparks taken from different parts of it are found to strike at different distances; so that, though we may, in general terms, adopt the rule that machine electric sparks prefer the shortest distances, yet the long sparks produced by the induction coil of Dr. Callan, in not one instance, that I observed, adopted that law. On the contrary, they appeared to most carefully avoid it, when taken between a point on the right hand and the slightly hollowed tin disk on the other.

According to the eye, the sparks started from the point, and struck indiscriminately on every part of the disk; and some of them, more wild or eccentric than the others, and as it were to set old-fashioned theories at defiance, actually jumped over its edge, and turned about, and struck the back of the disk,—thus imitating some well authenticated freaks of real flashes of lightning, which have been seen to go beyond, and, as it were, turn about and strike objects which they had apparently attempted to hit, but failing, turned round, and thus accomplished their original purpose in this most extraordinary or unscientific manner, as an old electrician might say.

Measured from the right-hand point to the striking spot on the left-hand disk, or another point used in place of it, the theoretic lengths of these sparks might be from fifteen to seventeen inches; but if we considered the twists and differences of direction of their several zig-zags, their real length in every case was much more; and in some instances it must have been, at least, twice as great as the distance from the point to the spot struck on the disk.

In several instances the long sparks appeared to the eye to form loops, but this was evidently due to their adopting a somewhat spiral form. This peculiarity of form has been also noticed in lightning. As equivalents of flashes of real lightning, these long sparks should possess great interest to electricians.

Though their motion in space appeared to us to be due to blind chance, yet that notion cannot be adopted by physicists, who must work out reasons for the whip-lash appearance of these sparks, instead of the taut cord or right line direction of other electric sparks. The long forked sparks produced by frictional electricity differ materially in their form and colour from those produced by the induced helix. The two kinds of sparks should be compared together at the same time, and as much as possible under similar circumstances.

No doubt the application of photography to real lightning on the great scale, and to these long induced electric sparks on the small scale, may lead us to the exact knowledge of their likeness or unlikeness in form, which the human eye cannot perceive. This application may have been made already; but, if it has, I am not aware of the fact. The suggestion will occur to any one who takes the same view of this subject with the author.

Hitherto the freaks of flashes of lightning in apparently avoiding conducting rods, and iron chimneys of steamers, and in striking objects near them, whether composed of good or bad conducting material, are facts which throw a great doubt on the advisability of using metallic conducting rods to buildings and ships. Theory in these cases is at fault: something remains to be worked out, to account for apparent exceptions to the law of "least distance;" and as these sparks appear to be flashes of lightning on a small scale, and perfectly manageable by the experimental philosopher, I notice them here in the hope that the law of their forms and directions may be studied by parties who have the means at their command for thoroughly sifting and tracing the causes of the phenomena noticed in this communication.

It was observed by Mr. Yeates, who was present at the lecture, that though there is a wonderful likeness in the forms of the long sparks produced by the induction coil and zigzag flashes of lightning, they were not accompanied with the smell of ozone, which is common to lightning and machine electric sparks; and that, consequently, there may be a real difference between the induced electric discharges and those which accompany ordinary electric phenomena. Indeed, theory would lead to the conclusion that these induced sparks are double, an

insensible or almost infinitely small interval of time separating them ; for otherwise they would neutralize each other at the moments of break of contact of the original helix connecting the electrodes of the battery.

To Dr. Callan we must all feel deeply indebted for the amount of labour, care, and intelligence he has devoted to chemical electricity, and its extension to the induced electric helix. We must congratulate him, also, on the great success which has attended his improvements and modifications of galvano-electric instruments ; which have, by economizing their production, brought them within the means of many experimentalists who, otherwise, could not expect to use or get access to such instruments ; and, finally, we may hope that he will continue his exertions, and his liberality in allowing scientific and curious people to see his great instruments in action—a favour which has led me to make this communication, in the hope that it may call more attention to the subject of induced electric action, on the great scale realized by Dr. Callan's *iron* helixes and galvanic batteries.

Mr. JOHN PURSER, Jun., M. A., read the following paper :—

ON THE APPLICATION OF CORIOLI'S EQUATIONS OF RELATIVE MOVEMENT
TO THE PROBLEM OF THE GYROSCOPE.

IN treating the problem of determining the apparent* motion of Foucault's gyroscope, different methods have been adopted.† Probably the most satisfactory is that of deducing the equations from the consideration of Corioli's "forces fictives" in relative motion. Corioli has shown that if the co-ordinate axes to which the movement of a system is referred are not fixed, but have a motion of their own in space, we may treat the question in all respects precisely as if these axes were fixed, provided we suppose superadded to the force (P) which acts upon any molecule two others, the first a force (P') equal and opposite to that which would impress on the molecule accelerations equal to those of a point coinciding at the instant with the molecule, but invariably connected with the moving axes—the second force (P'') perpendicular to the relative path of the molecule. Into the value or direction of this last it is unnecessary for the present purpose to enter more particularly.‡

* By apparent motion, here and afterwards, is meant the motion that would be apparent to a spectator on the earth's surface—that is, the motion with respect to co-ordinate axes invariably connected with the earth ; by absolute motion, the motion with respect to axes whose direction is fixed in space.

† This is the course taken by M. Quet, in a memoir that appeared on the subject of relative motion, in Liouville's Journal. My apology for reopening the question is, that in that paper the author seems to me to have needlessly complicated the problem by an assumption which, at first sight, appears calculated to simplify it. This will be explained in the sequel.

‡ For the deduction of the expressions for these forces in magnitude and direction, see "Duhamel, Cours de Mécanique," or Corioli's original papers in the "Journal de l'Ecole Polytechnique."